DEPARTMENT OF TRANSPORTATION WEATHER PROGRAMS

The Federal Aviation Administration (FAA) has the responsibility to provide national and international leadership in the optimization of aviation weather systems and services. This leadership is manifested through the management of a safe and efficient National Airspace System (NAS) and the encouragement of consensus and cooperation between government agencies, private weather services, research organizations, and user groups involved in aviation weather. The Federal Highway Administration (FHWA) manages programs that provide federal financial and technical assistance to the states, promotes safe commercial motor vehicle operations, and provides access to and within national forests and parks, native American reservations, and other public lands. Safety, efficiency, and mobility in these programs requires the incorporation and use of timely weather and road condition information. The Federal Railroad Administration promotes and regulates railroad safety. It also sponsors research to enhance railroad safety and efficiency, including support for improved collection, dissemination, and application of weather information to reduce hazards to train operations and to railroad employees. The Federal Transit Administration's mission is to ensure personal mobility and America's economic and community vitality by supporting high quality public transportation through leadership, technical assistance and financial resources.

FEDERAL AVIATION ADMINISTRATION

THE NATIONAL AIRSPACE SYSTEM OF THE FUTURE

In a proactive stroke to broaden the capabilities of the National Airspace System for the future, the 108th Congress and President Bush took the first critical step toward transforming our air transportation system by passing and signing into law *VISION 100 - Century of Aviation Reauthorization Act (P.L. 108-176)*. *VISION 100* calls for an integrated, multi-agency plan to transform the nation's air transportation system to meet the needs of the year 2025 while providing substantial near-term benefits. This Next Generation Air Transportation System (NGATS) Initiative will address critical safety and economic needs in civil aviation while fully integrating national defense and homeland security improvements into this future system.

Along with the private sector and academic community, the Federal Aviation Administration, NASA, the Departments of Commerce, Defense, Homeland Security, Transportation, and the White House Office of Science and Technology Policy are working together to design and build the NGATS.

The first product of this landmark effort was an *Integrated National Plan* delivered to Congress in December 2004. This strategic business plan lays out a common vision for the NGATS, establishes benchmarks for our success, and establishes a structure by which we can design and implement the changes we need to make. *VISION 100* also created the Joint Planning and Development Office (JPDO). Jointly managed by the FAA and NASA, and supported by staff from all the agencies involved, the JPDO serves as a focal point for coordinating the research related to air transportation for all of the participating agencies.

Overseeing the work of the JPDO is a Senior Policy Committee chaired by the Secretary of Transportation that includes senior representatives from the participating departments and agencies and the Director of the Office of Science and Technology Policy. Among its key responsibilities, the Senior Policy Committee provides policy guidance and review; makes legislative recommendations; and identifies and aligns resources that will be necessary to develop and implement the *Integrated National Plan*. DOT Secretary, Norman Mineta, chaired the first meeting of the Senior Policy Committee on September 26, 2003.

The JPDO has defined eight strategies that are the first steps towards creating the roadmap for NGATS. While the strategies deal with transforming specific areas of the air transportation system, they make up a larger whole and will integrate the sum of the efforts into building the NGATS system. The transformation strategies are:

- Develop Airport Infrastructure to Meet Future Demand.
- Establish an Effective Security System without Limiting Mobility or Civil Liberties.
- Establish an Agile Air Traffic System.
- Establish User-specific Situational Awareness.
- Establish a Comprehensive Proactive Safety Management Approach.
- Ensure Environmental Protection that Allows Sustained Economic Growth.
- Develop a System-wide Capability to Reduce Weather Impacts.
- Harmonize Equipage and Operations Globally.

For each of the eight *Integrated National Plan* strategies an an integrated product team (IPT) was formed.

The IPTs will be made up of government and private sector experts with extensive aviation experience. The IPTs will be responsible for applying best private and public sector practices to achieve that particular strategy's mission and objectives. The primary responsibility for assembling and leading each IPT belongs to one Federal agency.

The IPTs will establish detailed action plans that will break the project down into manageable tasks. Specific IPT activities include:

- Managing the planning and orchestrating the execution of all relevant work to complete the assigned strategy;
- Conducting analyses and trade studies to select and validate implementation alternatives;
- Analyzing changes currently underway, identifying gaps, and establishing the required Government and/or industry research and development activities to close necessary gaps;
- Coordinating with Government and private industry on research and development resources;
- Collaborating with industry on research and implementation for the initiative;
- Identifying non-technical approaches such as policy, regulation, and operational procedures;
- Establishing detailed requirements for individual mission areas;
- Conducting advanced concept and technology demonstrations;
- Creating a transition plan for implementation of products; and
- Creating public/private partnerships that include multi-agency, industry, and Government participation.

The JPDO is responsible for approving broad strategies of the IPTs as part of the *Integrated National Plan* and ensuring IPT plans and schedules are consistent with the roadmap and architecture.

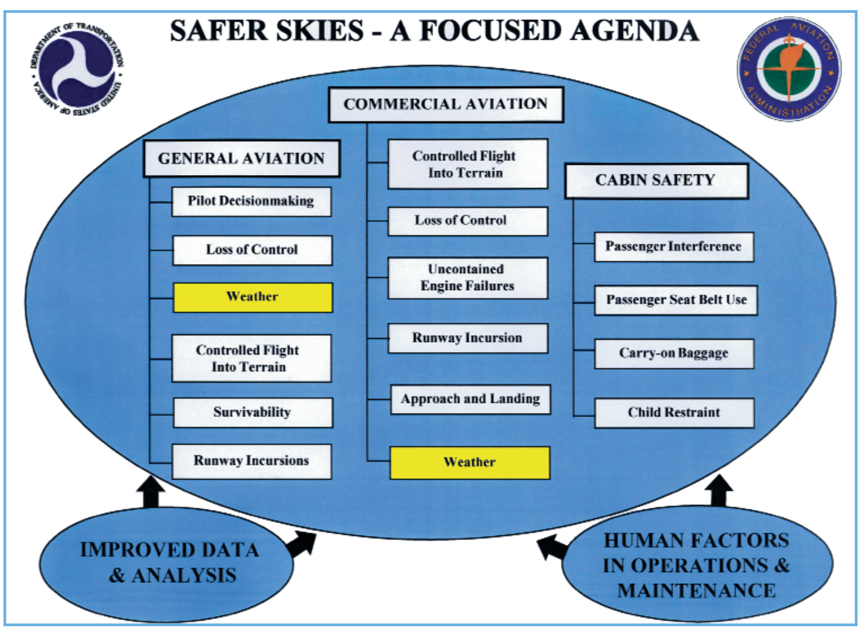
In addition, the NGATS Institute will support the NGATS mission by recruiting, selecting, and assigning private sector experts and technical resources to participate on IPTs and perform technical work for the IPTs and JPDO. These efforts will guarantee the establishment of a collective enterprise among key stakeholders to achieve the transformation, as well as to ensure that a process is created that is transparent and fully open to public scrutiny.

AVIATION WEATHER MANAGEMENT

Although the Department of Commerce's National Weather Service has the lead for the Weather IPT within the JPDO, the Federal Aviation Administration (FAA) continues to have the leadership role for the national aviation weather program requirements. As the leader, FAA must conduct continual coordination for identifying needs for aviation weather products and services among the Air Traffic Control organization, the aviation industry components and among service providers. The coordination process leads to opportunities to leverage efforts and resources to form partnerships in finding solutions in response to the needs. The *National Aviation Weather Program Strategic Plan* and the *National Aviation Weather Initiatives* are two documents that formalize the coordination and partnerships.

The FAA focus for aviation weather has been to promote safety first; then improve the NAS efficiency to reduce delays and re-routing due to weather. The Administrator has launched *The Safer Skies, A Focused Safety Agenda* which includes a government/industry Commercial Aviation Safety Team (CAST) and Joint Safety Analysis Teams (JSAT) to evaluate accident investigation reports to analyze the series of events leading to the accidents, and get a sense of what and how decisions were made in the course of the flight. Other teams, Joint Safety Implementation Teams (JSIT), using the findings of the JSAT, develop and recommend intervention actions to eliminate or reduce the causes or improve the actions in the decision making process. Training about the decision making process has been identified by these teams as a major part of the solution.

Aviation weather information is complex and highly perishable, is most useful when customers can successfully plan, act, and respond in ways that avoid accidents and delays. FAA will improve the ability of the aviation community to use weather information through a review and upgrade of airmen training and certification programs. FAA will also develop multi-



media training tools to support aviation safety and training initiatives. Funding has been requested to further this effort.

Weather has been made a standard consideration in all aspects of the operation and architecture of the NAS. Aviation weather needs from the field, Federal agencies, and industry are entered into the FAA Acquisition Management System (AMS) through which all new programs and changes to the NAS are processed, evaluated, validated, engineered to a requirement, and acquired. The new Air Traffic Organization (ATO) Service components have the responsibility to guide all initiatives through the AMS process and organization, including the Integrated Requirements Team, the Integrated Product Team, and the Decision Boards; to assure the development continues to meet the original need; and to guide the activity should the need evolve. Improvements to the AMS process facilitate non-system or non-hardware (e.g., service improvement or rule changes) solutions receiving the same rigorous evaluation and validation.

FAA has established an Aviation Weather Technology Transfer (AWTT) Board which addresses the key issues involved in bringing new weather capabilities in to the operational system. At key decision points, the board evaluates the maturity of the capability, its integration into the existing system, its supportability in the field, and the training program to prepare the users.

FAA relies on other Federal agencies for weather services and support, especially NOAA's National Weather Service (NWS) and its Aviation Weather Center. Requirements validated by FAA for domestic and International Civil Aviation Organization (ICAO) users are coordinated annually and supported through the agencies and contractual arrangements. All agencies' efforts in the area of aviation weather services are coordinated for use by everyone, as appropriate. Aviation weather technology includes the ways in which aviation weather information is gathered, assimilated, analyzed, forecast, disseminated, and displayed. The development of this technology also demands that consideration be given to human factors and the application of decision-making tools. FAA will support the use of technology to improve aviation weather information through integration of Federal and non-Federal resources. Automation, improved product and graphics generation, and dissemination to the cockpit are being developed as early opportunities to achieve these goals.

AVIATION WEATHER ACQUISITION AND SERVICES

One of the primary functions of the FAA ATO organization is the development and management of requirements for the FAA *Capital Investment Plan*. Recent projects in the Acquisition Management System (AMS) have focused on weather detection and display systems for pilots and air traffic controllers to ensure that aircraft avoid hazardous weather. The following paragraphs describe many of those projects.

The Integrated Terminal Weather System (ITWS) will integrate weather data from sensors in the terminal area to provide and display compatible, consistent, real-time products that require no additional interpretation by controllers or pilots--the primary users (Figure 3-DOT-1). ITWS will use data from automated surface observing systems, Doppler weather radars, and low-level wind-shear alert systems, together with NWS data and products, to forecast aviation impact parameters, such as convection, visibility, icing, and wind shear, including down bursts.

ITWS has been installed at 10 locations, of which 9 are in service. Installations are planned at 11 additional

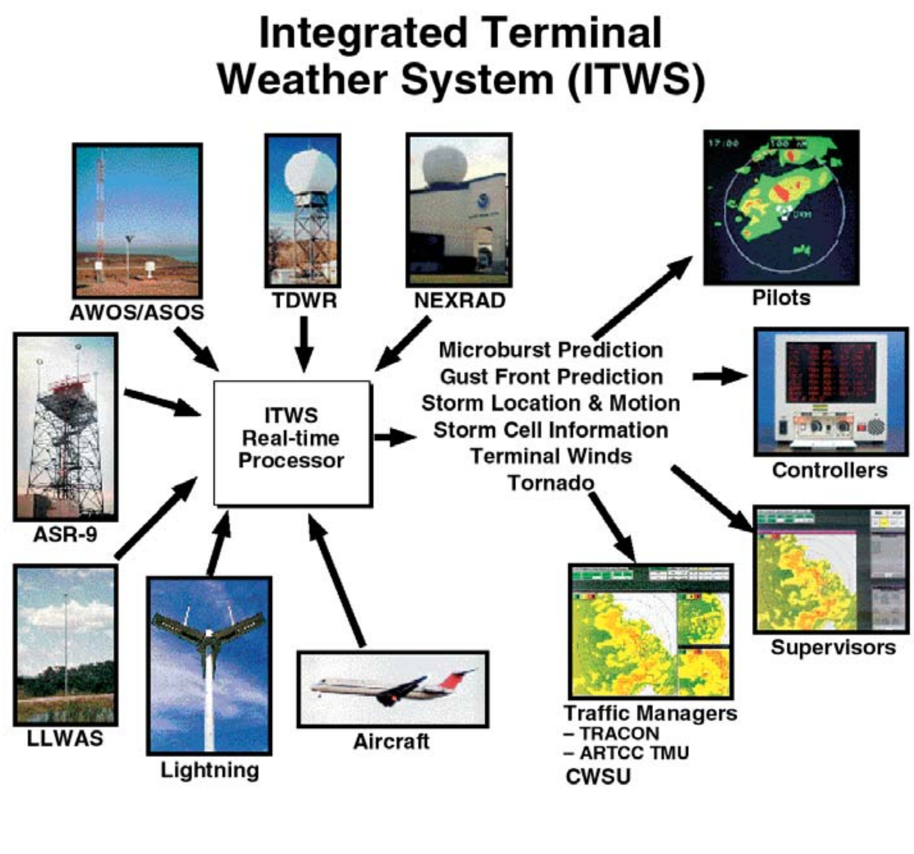
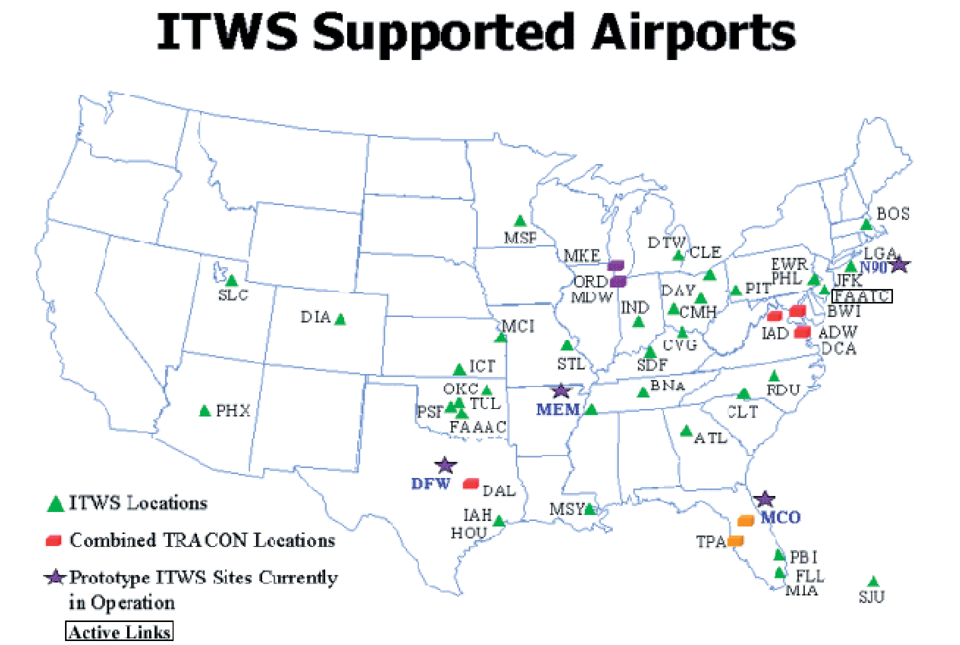


Figure 3-DOT-1. The ITWS integrates data from FAA and NWS sensors and systems to provide a suite of weather informational products.



locations by FY 2009. The current long range program has been limited to 22 ITWSs, which will cover about 30 high-activity airports that are supported by terminal doppler weather radars.

The Corridor Integrated Weather System (CIWS) is a demonstration program which will take some of the capabilities of the integration software of the ITWS and expand it to cover larger areas beyond the terminals. 'Corridor' in the name implies the area covered will be an elongated zone

Figure 3-DOT-2. Corridor Integrated Weather System (CIWS) Display

which may include a number of terminal areas. The demonstration area extends from Boston southward over New York as far as Washington and westward over Pittsburgh and Cleveland connecting to Chicago. The CIWS is expected to integrate information from the WSR-88D and ASR-9 radars and other observing sensors in the corridor to produce weather information products focused on current conditions affecting en route traffic in the corridor (Figure 3-DOT-2). It will produce two hour forecasts with trend information and a high-resolution echo tops product. There will be twelve sites, including six in the ARTCCs and one at the Command Center. The comprehensive plan calls for implementation by 2009; however the funding stream has been interrupted in 2006 which may delay implementation to a later year

The Terminal Doppler Weather Radar (TDWR) program consisted of the development, procurement, and installation of a new terminal weather radar based on Doppler techniques. TDWR units have been located to optimize the detection of microbursts and wind shear at selected airports with high operations and frequent weather impacts. In addition, TDWR has the capability to identify areas of precipitation and the locations of thunderstorms (Figure 3-DOT-3).

Microbursts are weather phenomenon that consists of an intense down draft with strong surface wind outflows. They are particularly dangerous to aircraft that are landing or departing. TDWR scanning strategy is optimized for microburst/wind shear detection. The radars are located near the airport operating areas in a way to best scan the runways as well as the approach and departure corridors. The displays are located in the tower cab and Terminal Radar Approach Control (TRACON).

The FAA has 47 TDWR systems. A software upgrade will integrates TDWR and low level wind shear alert system data has been integrated at 9 high traffic/high weather threat airports.

The Low Level Wind Shear Alert System (LLWAS) provides information on hazardous wind shear events that create unsafe conditions for aircraft landings and departures. A total of 110 airports have LLWAS. The 101 basic systems, LLWAS-2, consists of a wind sensor located at center field and 5 to 32 sensors near the periphery of the airport (Figure 3-DOT-4). A computer processes the sensor information and displays wind shear conditions on a ribbon display to air traffic controllers for relay to pilots. The improvement phase, referred to as LLWAS-Relocation/Sustainment (LLWAS-RS), will include expanding the network of sensors, developing improved algorithms for the expanded network, and installing new information/alert displays. The new information/alert displays will enable controllers to provide pilots with head wind gain or loss estimates for specific runways. These improvements will increase the system's wind shear detection capability and reduce false alarms. Improvements are also expected to reduce maintenance costs. LLWAS-

Figure 3-DOT-3. FAA Terminal Doppler Weather Radars provide supplementary wind and precipitation conditions for airport approach and departure.

RS deployment was completed this year.

The Weather Systems Processor (WSP) program provides an additional radar channel for processing weather returns and de-alias returns from the other weather channel in the ASR-9. The displays of convective weather, microburst, and other wind shear events will provide information for controllers and pilots to help aircraft avoid those hazards. All 34 units are in place and operating. Also, there is one mobile system in operation.

The Terminal Weather Information for Pilots (TWIP) program provides text message descriptions and character graphic depiction of potentially hazardous weather conditions in the terminal area of airports with installed TDWR systems. TWIP provides pilots with information on regions of moderate to heavy precipitation, gust fronts, and microburst conditions. The TWIP capability is incorporated in the TDWR software application. Text messages or character graphic depiction are received in the cockpit through the Aeronautical Radio Incorporated (ARINC) Communication Addressing and Reporting System (ACARS) data link system. A total of 47 TDWR systems are deployed, installed and commissioned. The TWIP capability is operational at most of the TDWR sites. Activation of TWIP at the remaining sites is dependent on availability of National Airspace Data Interchange Network (NADIN) II connectivity and program funding.

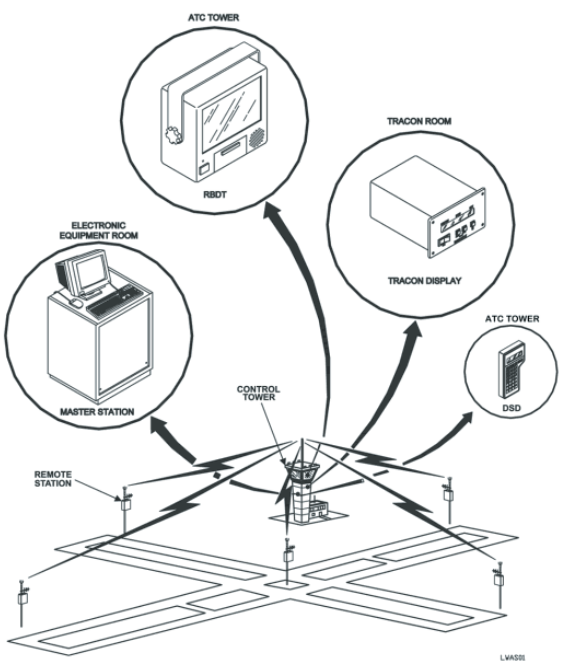


Figure 3-DOT-4. LLWAS equipment on an airfield.

The Flight Information System (FIS) Policy was implemented during FY 2001, through Government-Industry Project Performance Agreements (G-IPPAs) with two industry FIS data link service providers (ARNAV Systems, Inc. and Honeywell International, Inc.). Through the government-industry agreements, the FAA provides access to four VHF channels (136.425-136.500) in the aeronautical spectrum while industry provides the ground infrastructure for data link broadcasts of text and graphic FIS products at no cost to the FAA. Under the agreements, a basic set of text products are provided at no cost to the pilot users while industry may charge subscription fees for other value-added text and graphic products.

The FAA FIS data link program will continue development of necessary standards and guidelines supporting inter-operability and operational use. In addition, the need and feasibility for establishing a national capability for collecting and distributing electronic pilot reports (E-PIREPs) from low-altitude general aviation operations is being evaluated. A concept analysis has been initiated to define the need for transition and evolution of FIS data link services supporting the future NAS architecture including Free Flight operations.

SURFACE WEATHER OBSERVING PROGRAM

Aviation Weather Observations. The FAA has taken responsibility for aviation weather observations at many airports across the country. To provide the appropriate observational service, FAA is using automated systems, human observers, or a mix of the two. It has been necessary to place airports into four categories according to the number of operations per year, any special designation for the airport, and the frequency at which the airport is impacted by weather.

Level D service is provided by a stand-alone Automated Weather Observing System (AWOS) or an Automated Surface Observing System (ASOS). In the future, Level D service may be available at as many as 441 airports.

Level C service includes the ASOS/AWOS plus augmentation by tower personnel. Tower personnel will add to the report observations of thunderstorms, tornadoes, hail, tower visibility, volcanic ash, and virga when the tower is in operation. Level C service includes about 301 airports.

Level B service includes all of the weather parameters in Level C service plus Runway Visual Range (RVR) and the following parameters when observed--freezing drizzle versus freezing rain, ice pellets, snow depth, snow increasing rapidly remarks, thunderstorm/lightning location remarks, and remarks for observed significant weather not at the station. Level B service includes about 58 airports.

Level A service includes all of the weather parameters in Level B service plus 10-minute averaged RVR for long-line transmission or additional visibility increments of 1/8, 1/16, and 0 miles. Level A service includes about 70 airports.

Automated surface aviation weather observing systems will provide aviation-critical weather data (e.g., wind velocity, temperature, dew point, altimeter setting, cloud height, visibility, and precipitation type, occurrence, and accumulation) through the use of automated sensors. These systems will process data and allow dissemination of output information to a variety of users, including pilots via computer-generated voice.

Automated Weather Observing Systems (AWOS) was deployed at over 200 airports to provide the basic aviation weather observation information directly to pilots approaching the airport. The majority of these systems were installed at various non-towered airports to enhance aviation safety and the efficiency of flight operations by providing real-time weather data at airports that previously did not have local weather reporting capability. These systems are built to the standards of quality necessary to ensure the safety of flight operations and are available off-the-shelf as a commercial product. There remain 198 AWOSs.

Automated Surface Observing Systems (ASOS). In a joint program with NOAA NWS, the FAA has procured, installed, and operates ASOS at the remaining airports where the FAA provides observations and at additional non-towered airports without weather reporting capabilities in accord with the levels of service listed above. Production is complete and the FAA has 569 systems installed and commissioned.

Aviation Weather Sensor Systems (AWSS), a new program, will have capability similar to ASOS (Figure 3-DOT-5). However, the AWSS is a direct acquisition of the FAA--not from the joint ASOS program. Production was completed in CY 2005.

The AWOS/ASOS Data Acquisition System (ADAS) functions primarily as a message concentrator and will collect weather messages from AWOS and ASOS equipment located at controlled and non-controlled airports within each ARTCC's area of responsibility. ADAS will distribute minute-by-minute AWOS/ASOS data to the Weather and Radar Processor (WARP) within the air route traffic control center in which it is installed. ADAS will also distribute AWOS data to the NADIN which will in-turn forward the data to the Weather Message Switching Center Replacement (WMSCR) for further distribution. Field implementation of ADAS is complete.

The Automated Lightning Detection and Reporting System (ALDARS) is a system adjunct to the ADAS. ALDARS collects lightning stroke information from the National Lightning Detection Network (NLDN) and disseminates this data to AWOS/ASOS for the reporting of thunderstorms in METAR or SPECI observations, when appropriate. The use of ALDARS eliminates the need for manual reporting of thunderstorms and increases the number of airports where thunderstorms will be reported. ALDARS is completely operational.

Stand Alone Weather Sensors (SAWS) are back-up systems for some AWOS/ASOS sensors at locations where no other back-up capability is available. SAWS have been demonstrated and full delivery is nearly completed. The full deployment will comprise up to 307 units.

Figure 3-DOT-5. Aviation Weather Sensor Systems an ASOS like supplement for observations.

ASOS Controller Equipment- Information Display System (ACE-IDS) is an electronic cabinet of displays available to the controller at his work station (Figure 3-DOT-6). It provides graphics of information which comes from many sources that originate at many nodes of an LAN which includes, but is not limited to, weather related parameters, observations, and other automated weather products. This system is designed specifically to support operations in high-volume, high-tempo Terminal Radar Approach Control (TRACON) facilities. They are installed at the following TRACONs: Atlanta, Boston, Dallas-Fort

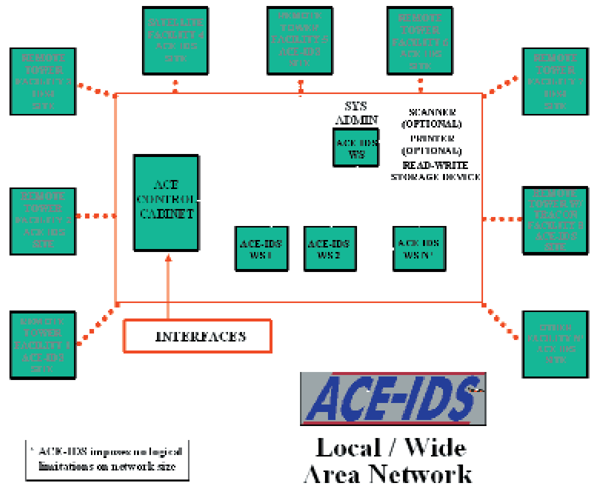


Figure 3-DOT-6. ASOS Controller Equipment- Information Display System (ACE-IDS)

Worth, Honolulu, Northern California (San Francisco), Oklahoma City, Potomac (Wash. D.C.), Saint Louis, and Seattle.

AWOS for Non-Federal Applications. Under the Airport Improvement Program (AIP), state and other local jurisdictions may justify to the FAA their need to enhance their airport facilities. Upon approval, these improvements may be partially funded by the FAA using resources from the Airway Trust Fund. The local airport authority becomes responsible for the remainder of the funding necessary to complete the procurement, as well as the funding for the regular maintenance. The addition of an AWOS is one of the improvements that qualify for AIP funding assistance. Systems that qualify must meet certain standards which are defined in an FAA Advisory Circular on *Non-Federal Automated Weather Observing Systems.*

There are more than 275 non-Federal AWOS locations. Some of these are capable of reporting through a geostationary communications satellite. These observations will be entered into the national network for use in support of the NAS and the national weather network.

The New Generation Runway Visual Range (NRVR) program provides for a new generation RVR sub-element of the NAS. The NRVR provides runway visual range information to controllers and users in support of precision landing and take-off operations. The NRVR incorporates state-of-the-art sensor technology and embedded remote maintenance monitoring. The FAA plans to procure and install these NRVR systems at all new qualifying locations. FAA plans also call for the replacement of many existing RVRs in the NAS inventory.

The NRVR provides for near real-time measurement of visibility conditions along a runway (up to three points along the runway can be measured-- touchdown, midpoint, and roll-out) and reports these visibility conditions to air traffic controllers and other users. The system automatically collects and formats data from three sensors: a visibility sensor--forward scatter meters will replace the transmissometers currently in use; a runway light intensity monitor for both runway edges and center-line lights; and an ambient light sensor which controls computer calculations using a day or night algorithm. The data processing unit calculates runway visibility products and distributes the products to controllers and other users.

NRVR visibility sensors will be deployed at 308 airports. Delivery of the NRVR sensors began in November 1998. To date, 230 units have been delivered and 185 have been commissioned. At the current levels of annual funding, the program will be completed the deployment by the end of CY 2009.

The FAA procured the Operational and Supportability Implementation System (OASIS) to improve weather products, flight information, aeronautical data collection, analysis, and timeliness of dissemination, thereby enhancing the safety and efficiency of the NAS. OASIS will replace the Model-1 Full Capacity Flight Service Automation System, which includes the Aviation Weather Processor. OASIS will also integrate the Interim Graphic Weather Display System functions and include several automated flight service data handling capabilities. This configuration will be an initial deployment capability. Operational testing began in 1999; 16 systems have been deployed from the original plan of 61. Future enhancements leading to the full capability deployment will include: interactive alphanumeric and graphic weather briefings; direct user access terminal (DUAT) service functionality; automated special use airspace; and training support. OASIS will support flight planning, weather briefings, NOTAM service, search and rescue, and pilot access terminal services. Note: This program will be suspended in FY 2008.

The Next Generation Weather Radar (NEXRAD), known operationally as the Weather Surveillance Radar-1988 Doppler (WSR-88D), is a multi-agency program that defined, developed, and implemented the new weather radar. Field implementation began in 1990 and was completed in 1996. There are a total of 161 WSR-88D systems deployed. The FAA sponsored 12 systems in Alaska, Hawaii, and the Caribbean. DOC and DOD WSR-88Ds provide coverage over the continental U.S..

The FAA emphasized the development of WSR-88D algorithms that take advantage of the improved detection of precipitation, wind velocity, and hazardous storms. The FAA also stressed that these algorithms provide new or improved aviation-oriented products.

These improvements in detection of hazardous weather will reduce flight delays and improve flight planning services through aviation weather products related to wind, wind shear, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, and mesocyclones and tornadoes. WSR-88D data provided to ATC through the WARP will increase aviation safety and fuel efficiency.

In addition, the three funding agencies support the field sites through the WSR-88D Radar Operations Center (ROC) at Norman, Oklahoma. The ROC provides software maintenance, operational troubleshooting, configuration control, and training. Planned product improvements include a shift to an open architecture, new antenna design, dual polarization, and the development of more algorithms associated with specific weather events, such as hurricanes.

The Air Route Surveillance Radar (ARSR-4) provides the ARTCCs with accurate multiple weather levels out to 200 nautical miles. The ARSR-4 is the first enroute radar with the ability to accurately report targets in weather. The ARSR-4 can provide weather information to supplement other sources. The ARSR-4 is a joint FAA/USAF funded project. Forty joint radar sites were installed during the 1992-1995 period.

The Weather and Radar Processor (WARP), has replaced the Meteorologists Weather Processor to provide aviation weather information to the Center Weather Service Units. WARP automatically creates unique, regional, WSR-88D-based, mosaic products, and sends these products, along with other time-critical weather information, to controllers through the Display System Replacement and to pilots via the FIS. WARP greatly enhances the dissemination of aviation weather information throughout the NAS. WARP underwent operational testing and evaluation in early FY 2003 and is operationally fielded at the 21 ARTCCs and the command center. Others systems used for enhancements, testing, and software support bring the total to 25 systems.

The Direct User Access Terminal (DUAT) system has been operational since February 1990. Through DUAT, pilots are able to access weather and NOTAMs and also file their IFR and/or VFR flight plans from their home or office personal computer.

AVIATION WEATHER COMMUNICATIONS

It should be noted that FAA communications systems are multi-purpose. Weather data, products, and information constitute a large percentage of the traffic, as do NOTAMS, flight plans, and other aeronautical data.

The National Airspace Data Interchange Network (NADIN II) packet-switched network was implemented to serve as the primary inter-facility data communications resource for a large community of NAS computer subsystems. The network design incorporates packet-switching technology into a highly connected backbone network which provides extremely high data flow capacity and efficiency to the network users. NADIN II consists of operational switching nodes at two network control centers (and nodes) at the National Aviation Weather Processing Facilities at Salt Lake City, Utah, and Atlanta, Georgia. It will interface directly to Weather Message Switching Center Replacement (WMSCR), WARP, ADAS, TMS, and the Consolidated NOTAM System. NADIN II also may be used as the intra-facility communications system between these (collocated) users during transition to end state.

The Weather Message Switching Center Replacement (WMSCR) replaced the Weather Message Switching Center (WMSC) located at FAA's National Communications Center (NATCOM), Kansas City, Missouri, with state-of-the-art technology. WMSCR performs all current alphanumeric weather data handling functions of the WMSC and the storage and distribution of NOTAMs. WMSCR will rely on NADIN for a majority of its communications support. The system will accommodate graphic data and function as the primary FAA gateway to the NWS National Centers for Environmental Prediction (NCEP)--the principal source of NWS products for the NAS.

To provide for geographic redundancy, the system has nodes in the NADIN buildings in Atlanta, Georgia, and Salt Lake City, Utah. Each node supports approximately one-half of the U.S. and will continuously exchange information with the other to ensure that both nodes have identical national databases. In the event of a nodal failure, the surviving node will assume responsibility for dissemination to the entire network.

Currently, specifications for an upgrade or replacement for the WMSCR are being formulated. The needs, when developed, will be entered into the AMS process for validation and acceptance into the NAS architecture.

The Flight Information Service (FIS) is a new communication system to provide weather information to pilots in the cockpit. FIS is a partnership program among the government and private industry with the government providing the base information and the bandwidth while the private companies provide the broadcast and value-added products. New products are screened for technical suitability and value to the pilots. Two companies have demonstrated preliminary products and capability.

The Worldwide Aeronautical Forecast System (WAFS) is a three geosynchronous satellite-based system for collecting and disseminating aviation weather information and products to/from domestic or international aviation offices as well as in-flight aircraft. The information and products are prepared at designated offices in Washington, District of Columbia, and Bracknell, United Kingdom. The U.S. portion of WAFS is a joint project of the FAA and NWS to meet requirements of the ICAO member states. FAA funds the satellite communications link and the NWS provides the information/product stream.

Two of the three satellites are funded by the U.S.. The first is located over the western Atlantic with a footprint covering western Africa and Europe, the Atlantic Ocean, South America, and North America (except for the West Coast and Alaska). The second U.S.-funded satellite is positioned over the Pacific and covers the U.S. West Coast and Alaska, the Pacific Ocean, and the Pacific rim of Asia. The third satellite, operated by the United Kingdom, is stationed over the western Indian Ocean and covers the remaining areas of Europe, Asia, and Africa. The data available via WAFS include flight winds, observations, forecasts, SIGMETs, AIRMETs, and hazards to aviation including volcanic ash clouds.

The System Wide Information Manager is a new concept developed in conjunction with NGATS to support NAS operations in the 2025 timeframe. For all facets of the NAS operations, all data will be resident on a 'data cube' which will be accessible to all users; thus assuring that all users will have the same data. This will assure that collaborative decision making will benefit from the same situational awareness, weather and traffic programs.

AVIATION WEATHER RESEARCH PROGRAM

Working closely with the Integrated Product Team for Weather/Flight Services Systems, ATO sponsors research on specific aviation weather phenomena which are hazardous and/or limiting to aircraft operations. This research is performed through collaborative efforts with the National Science Foundation (NSF), NOAA, NASA, and the Massachusetts Institute of Technology's Lincoln Laboratory. A primary concern is the effective management of limited research, engineering, and development resources and their direct application to known deficiencies and technical enhancements.

IMPROVED AIRCRAFT ICING FORECASTS. The purpose of this initiative is to establish a comprehensive multi-year research and development effort to improve aircraft icing forecasts as described in the FAA Aircraft Icing Plan. The objectives of this plan are to develop: (1) an icing severity index, (2) icing guidance models, and (3) a better comprehension of synoptic and mesoscale conditions leading to in-flight icing. The result of this effort will be an improved icing forecasting capability that provides pilots with more timely and accurate forecasts of actual and expected icing areas by location, altitude, duration, and potential severity.

CONVECTIVE WEATHER FORECASTING. The purpose of this research effort is to establish more comprehensive knowledge of the conditions that trigger convection and thunderstorms and, in general, the dynamics of a thunderstorm's life cycle. The program will lead to enhanced capability to predict growth, areal extent, movement, and type of precipitation from thunderstorms. Gaining this forecast capability will allow better use of the airspace and help aircraft avoid areas with hazardous convective conditions (Figure 3-DOT-7).

MODEL DEVELOPMENT AND ENHANCEMENT. This research is aimed at developing or improving models to better characterize the state of the atmosphere and stratosphere in general, with specific emphasis on the flight operation environment specifically, with the aim to provide superior aviation weather products to end users.

AVIATION FORECAST AND QUALITY ASSURANCE.

The Product Development Team (PDT) for the Aviation Gridded Forecast System is working on the development of products for dissemination on the Aviation Digital Data System. New algorithms will be developed to present hazardous conditions in the flight operations environment. They will develop a process for automated production of the SIGMETs. There will be capability to assure quality and a real-time verification process.

WEATHER SUPPORT TO DEICING DECISION MAKING (WSDDM). This system develops products that provide forecasts on the intensity of snow and freezing rain, and how or when these phenomena will change in the short term. This information is needed by airport management to determine when an aircraft will require deicing before take-off. The water content of snow is believed to be an important factor. The output product is designed for non-meteorological aviation users and has been demonstrated at three different airports. Development work has been completed and FAA has made this system available to airport authorities who wish to use it as a decision aid.

CEILING AND VISIBILITY. A development and demonstration is underway in the San Francisco Bay area. The project will have unique sensors and the data will be used in new algorithms to develop improved forecasts. The project will continue over a number years as the progress is evaluated. This project is a joint effort with other Federal agencies and some of the effort is performed by academic researchers.

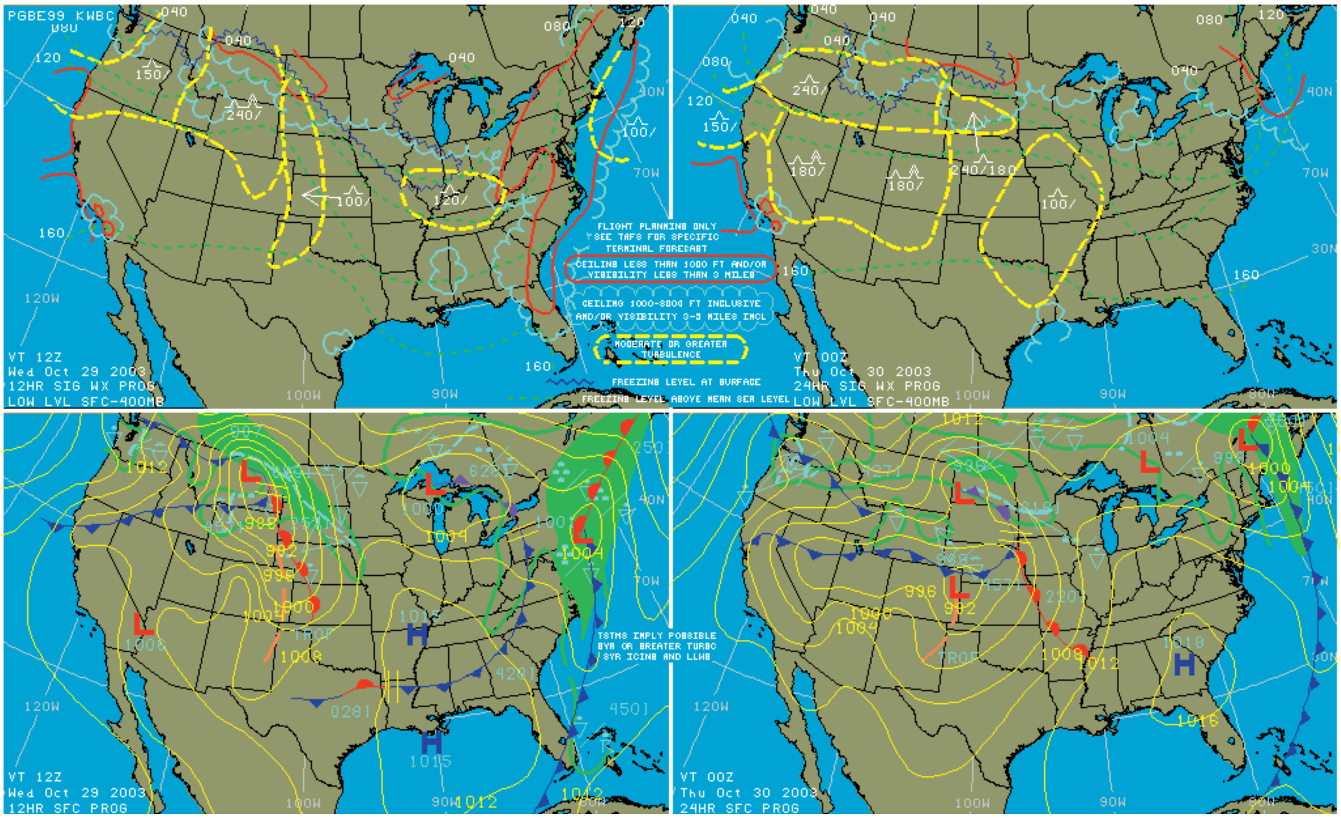


Figure 3-DOT-7. 4-panel Low Level Significant Weather graphics are produced by the Aviation Weather Center and accessible to pilots from their web site. (Source: AWC web site)

TURBULENCE. In addition to the work being performed by the JSAT under the Safer Skies Program, a PDT has a seven year plan to evaluate wind shear and turbulence around and on the approaches to Juneau, Alaska. Also, they are working with certain airlines to install instruments on aircraft with the capability to measure turbulence as sensed on the aircraft and report this information automatically. The data will be used to verify forecasts and to develop a standard index to report and warn for turbulence.

NEXRAD ENHANCEMENTS. Work is continuing to develop improvements to the existing products and to develop new graphic products. Hardware and software pre-planned product improvements are are being pursued. This is a joint effort among DOT, DOD, and DOC.

Under the auspices of the OFCM, FAA is investigating the possibilities of developing multi-use phased array radar to accomplish both weather surveillance and monitor aircraft movement in controlled airspace.

SPACE WEATHER. Space Weather is of concern to the FAA in several areas of operations and regulations. Ionospheric scintillation creates certain errors in the Global Positioning System that affects navigation, especially for instrument approaches to airports. In programs for Wide Area and Local Area Augmentation Systems (WAAS and LAAS) corrections for these effects are being developed. This will be a very important advance to promote the Free Flight management of the National Airspace System. In addition, the effects on the ionosphere have grave impacts on the use of high frequency communications which are essential in air traffic control of flights across the oceans and over the poles of the Earth.

FAA is embarking in research at the Civil Aeromedical Institute in Oklahoma City, OK, on the radiation effects on fetuses of newly pregnant women when flying at high altitudes and at high latitudes where exposure is increased. The exposure of flight crews to this hazard will be measured to determine if repeated flights in this regime may accumulate deleterious results.

FAA planners for commercial space operations are working on the weather requirements to set criteria for space launch activities. The commercial launch sites in California, Florida and Virginia are co-located with government sites where the weather support is available. However, at the new commercial space launch site in Kodiak, Alaska new criteria must be developed and established for standard procedures.

FEDERAL PROGRAMS IN SUPPORT OF ROAD WEATHER

THE ROAD WEATHER MANAGEMENT PROGRAM

The Federal Highway Administration (FHWA) coordinates a number of activities aimed at improving safety, mobility, productivity, environmental quality and national security on the nation's highways during weather threats. These activities include identification of weather impacts on the roadway environment, traffic flow, and the operational decisions that are made because of them. It includes research to advance the state of the art concerning road weather management tools, as well as documentation and promotion of the best practices. The FHWA acts through federal aid and national coordination since it does not operate the highway system or environmental observing systems that serve state and local highway operators, private road users, and the traveling public. FHWA activities are conducted as partnerships with other public agencies, the private sector, and universities.

As of 1997, coordination of FHWA weather related activities has been centered in the Road Weather Management Program (RWMP) within the FHWA's Office of Transportation Operations. From the beginning, an important goal of this program has been to help promote road weather research and development and this objective and its associated roadmap was further defined in 2005 by the passage of the *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)*. Title V, Subtitle C - *Intelligent Transportation System Research*, Section 5308 of this bill contains specific reference to a "Road Weather Research and Development Program," the scope of which includes: maximizing the use of available road weather information and technologies; expanding road weather research and development efforts to enhance roadway safety, capacity, and efficiency; minimizing environmental impacts; and promoting technology transfer of effective road weather scientific and technological advances. The bill directs the Secretary of the USDOT to solely carry out research and development called for in the National Research Council's (NRC) report entitled, *Where the Weather Meets the Road, A Research Agenda for Improving Road Weather Services*. This effort includes: integrating existing observational networks and data management systems for road weather applications; improving weather modeling capabilities and forecast tools, such as the road surface and atmospheric interface; enhancing mechanisms for communicating road weather information to users (such as transportation officials and the public); and integrating road weather technologies into an information infrastructure. The bill also includes three guiding principles which are to: enable efficient technology transfer; improve education and training of road weather information users (such as state and local transportation officials and private sector transportation contractors); and coordinate with transportation weather research program in other modes, such as aviation.

Funding authorized for Section 5308 is $5.0 million per year for the years 2006 to 2009, and the Secretary was directed to give preference to applications with significant matching funds from non-Federal sources.

The FHWA Road Weather Management Program team is responsible for executing the program in coordination with the ITS Joint Program Office. The goals and objectives of the RWMP and its associated roadmap have been modified to align with the legislation, though such modification was minimal since the existing program already aligned very closely with the NRC report. Numerous efforts and initiatives within the RWMP are satisfying the requirements in the bill, including the Maintenance Decision Support System (MDSS), the *Clarus* initiative, and the Memorandum of Understanding between the FHWA and NOAA.

Some of the activities occurring within the RWMP include:

THE STRATEGIC HIGHWAY RESEARCH PROGRAM (SHRP)

Congress established the Strategic Highway Research Program (SHRP) under the 1987 Surface Transportation Act. SHRP examined a number of different subject areas including winter maintenance operations on the nations highways. The research program was active until 1993, producing specifications, testing methods, equipment, and advanced technologies. Following the success of the five-year effort, the FHWA coordinated a national program, entitled SHRP Implementation, to work with state and local highway agencies to implement and evaluate the products. The American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board (TRB) administered this program in coordination with FHWA. The SHRP Implementation web site (www4.trb.org/trb/dive.nsf/web/shrp_implementation) contains information on the SHRP Lead States Program, SHRP products under evaluation and implementation, and SHRP in general.

THE INTELLIGENT TRANSPORTATION SYSTEMS (ITS) PROGRAM

The Intermodal Surface Transportation Efficiency Act of 1991, established the ITS Program, including its research program that funds the FHWA Road Weather Management Program activities. This program is overseen by the ITS Joint Program Office (ITS-JPO), which is a cross-modal office hosted in the USDOT's Research and Innovative Technology Administration. While ITS initially focused on automated highways and metropolitan areas, a rural focus was initiated in 1996. The rural ITS program identified maintenance and weather as additional ITS focus areas, and recognized the need for total integration of the maintenance, traffic, and emergency management functions across wide areas and between states. The following research activities are examples that fall within this overall weather-across-ITS strategy:

Vehicle Infrastructure Integration (VII) Initiative

This initiative (www.its.dot.gov /vii/index.htm) is exploring the potential of creating a data sharing communication system that could support vehicle-to-vehicle and vehicle-to-infrastructure communications. The system, once implemented, will provide real-time travel and weather information to both the public sector and private industry, and also support advanced safety applications. VII could be a significant enabler of weather-related applications, such as vehicle-based sensors that gather environmental data system-wide. The resulting communications network would allow weather, traffic and other information to be transmitted to transportation operators, providing a real-time view of the conditions on every major road within the transportation network. Such concepts will be explored as the initiative matures. The functional architecture and requirements for VII are under development. Preliminary documentation describes some of the weather-related data items that could be directly measured or inferred from vehicle sensor systems including precipitation detection, ambient air temperature, fog or visibility information, and road traction state or mobility.

National ITS Architecture and ITS Standards

Intelligent Transportation Systems use open system principles and are based upon the National ITS Architecture - a modularly defined set of information processes with known protocols for exchanging information between modules. While road weather information was not an original focus of the National ITS Architecture, it has since been captured through the Maintenance and Construction Operations (MCO) user service. MCO development included the definition of a Road Weather Information Service terminator designed to complement the existing Weather Service terminator. Together, these represent the division of responsibility for road weather information, provided largely by private vendors and based on ESS observations, and weather information in general. The interfaces between the two types of services are then defined as being outside of the ITS, although the FHWA continues to maintain an active interest in their development.

It is hoped that further detailing of weather applications in traffic and emergency management will lead to further architecture developments in the years ahead. As the interface between the ITS and evolving national weather information systems becomes better defined, the National ITS Architecture and standards will provide a technical basis for integration and promotion of open system principles. Version 5.1 of the National ITS Architecture can be found at http://itsarch.iteris.com/itsarch/.

Environmental Observing Systems

Over 2,400 ESS are owned by state transportation agencies in the United States as shown in Figure 3-DOT-8. More than 2,000 of these ESS are field components of the Road Weather Information Systems. ESS placed in the field are generally fixed, with in situ sensors for the usual atmospheric weather variables, as well as pavement and subsurface temperature probes, pavement chemical concentration or pavement freezing point. In some cases, and potentially over all road mileage, mobile environmental sensors are being deployed to observe weather and pavement conditions from vehicles. An important application of the mobile, and potentially remote, sensing is thermal mapping of road segments. This technique provides snapshots of complete pavement temperature profiles and is used both to select fixed ESS sites and to spatially predict temperatures based on time series predictors at the fixed stations. FHWA-funded research is also investigating the potential to extract surface weather and road condition data from standard traffic camera imagery. The potential value of this research is significant considering the fact that in 2004, there were already 4000 Closed Circuit Television (CCTV) traffic cameras deployed nationwide.

At present, ESS data across the United States are neither integrated nor open. The data are not centrally collected, in a standard format, available to all users, nor uniformly used. A USDOT-sponsored initiative entitled *Clarus* aims to correct this shortfall by designing and demonstrating an integrated road weather observational network, and establishing a partnership to facilitate deployment of a nationwide surface transportation weather observing system. The long-term vision of *Clarus* is that all data from state DOT ESS will be routinely collected, quality-checked, and translated into an open standard format. Quality checking algorithms and direct feedback to state DOT points of contact will improve agency awareness of sensor status. Access to robust and calibrated data will be provided through an open Internet data portal. The *Clarus Concept Of Operations* and the *Clarus* system design has been completed. A Proof-of-Concept demonstration occurred in 2006, and regional demon-

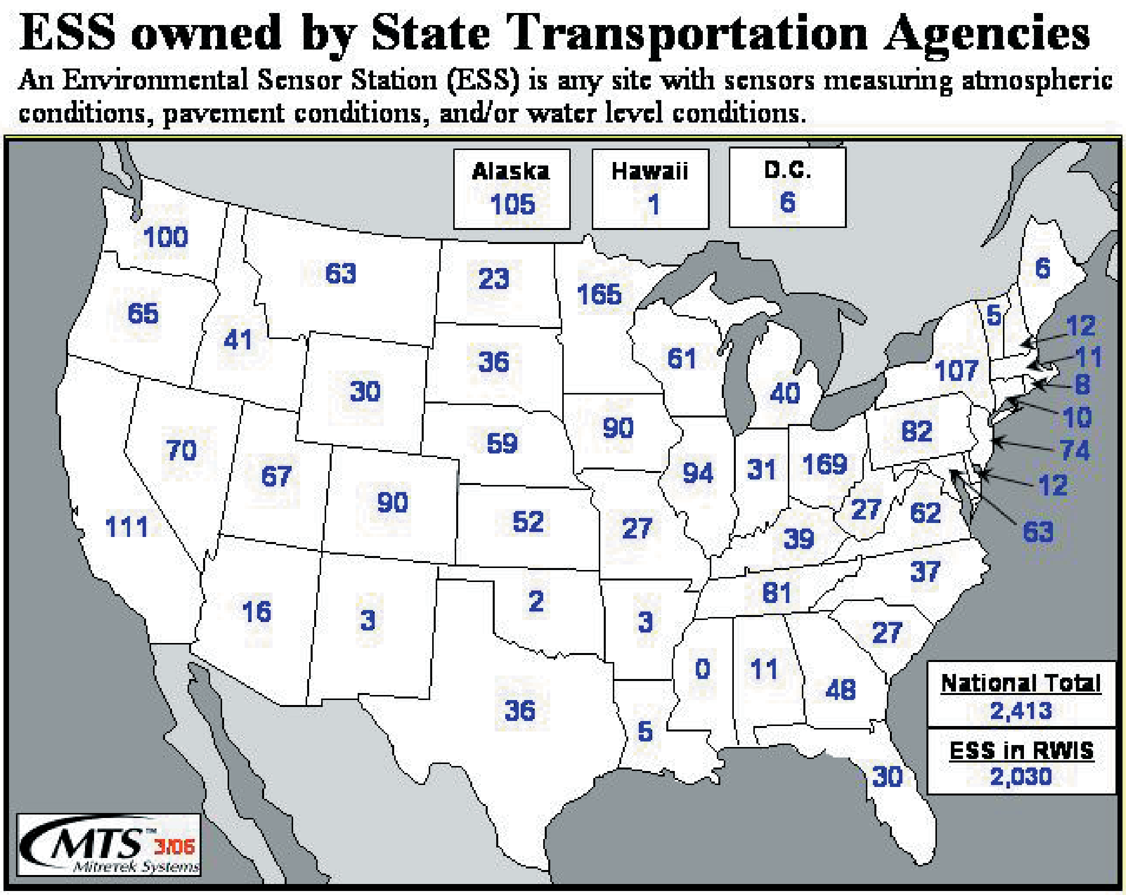


Figure 3-DOT-8. Census of deployed Environment Sensor Station (ESS) units. An ESS is a site measuring atmospheric, pavement and/or water level conditions. Many state transportation agencies deploy ESS as field components of Road Weather Information Systems (RWIS). As shown on the map, there are over 2,400 ESS owned by state transportation agencies. Most of these stations (i.e., 2,000) are part of RWIS and used to support road maintenance activities. The other environmental sensor stations are deployed for various applications including flood monitoring and aviation.

strations are planned for 2007.

In order to address some of the issues related to surface weather observations, the FHWA is participating in several OFCM projects including the Weather Information for Surface Transportation Working Group, the Phased Array Radar (PAR) Joint Action Group, the Joint Action Group for Joint Urban Test Beds (JAG/JUTB), the Fire-Weather Joint Action Group, the Committee on Environmental Information Systems and Communication, and the Committee for Environmental Services, Operations, and Research Needs (CESORN). FHWA is also participating in NOAA efforts to explore the modernization of the cooperative observer network and development of a national surface weather observing system.

From 2001 to 2003, the FHWA sponsored five research projects, under the Cooperative Program for Meteorological Education and Training (COMET) (www.comet.ucar.edu), which became the first to add state DOTs to the traditional partnerships of NWS forecast offices and universities. The COMET projects in Iowa, Nevada, New York, Pennsylvania, and Utah fostered the sharing of environmental data and facilitated advanced meteorological modeling to enhance road weather forecasts. Ultimately, these efforts will contribute to the development of decision support tools for winter maintenance managers, traffic managers, and the traveling public. Lessons learned from these projects can help all state DOTs better manage RWIS networks and achieve maximum utility from RWIS data.

In order to enhance observation capabilities and define requirements for road weather observing systems, the Road Weather Management Program worked with the Aurora Pooled Fund Program and the AASHTO Snow and Ice Cooperative Program to produce the *Road Weather Information System ESS Siting Guidelines* (http://ops.fhwa.dot.gov/publications/ess05/). The guidelines, published in 2005, provide a set of recommendations to support uniform siting of ESS that collect road and weather observations for RWIS, and are intended to improve the usefulness of road weather information derived from these observations. The Road Weather Management Program will facilitate the adoption and implementation of the guidelines in transportation agencies through targeted research and deployment activities.

Decision Support

Transportation system managers and users identified three critical surface weather information requirements as the trinity of "relevance, accuracy and timeliness". Although significant progress continues to be made by both the public and private sectors in providing new technologies to meet these requirements, a significant gap has developed between the amount of increasingly good and plentiful surface weather information, and the amount of support available for effective operational decision-making. Assisting and supporting the research and development of ways to overcome this gap has become an important initiative within the FHWA.

Decision support is where surface weather data needs to be customized since each operational decision is specific to a type of road weather management strategy, a particular place and time, and the characteristics of the decision maker (their expertise, their location, their information processing equipment). Road weather management strategies mitigate weather impacts by advising motorists of prevailing and predicted conditions (e.g., traveler information), controlling traffic flow and roadway capacity (e.g., weather-responsive traffic signal timing, road closure), and/or treating roads to minimize or eliminate weather threats (e.g., plowing, anti-icing/deicing).

In 1999 and 2000, decision support requirements, first generally and then specifically for winter road maintenance, were studied in the Surface Transportation Weather Decision Support Requirements (STWDSR) project. This project used weather threat scenarios to identify specific decisions made in winter road maintenance, their timing, and the expected confidence of the decisions at various time horizons. General requirements for emergency managers, traffic managers, and road users were also defined. The STWDSR project became an important contributor to the OFCM's *Weather Information for Surface Transportation (WIST)* needs analysis, the National ITS Architecture modifications, and to the Maintenance Decision Support System (MDSS) prototype project.

Along with the Maintenance Decision Support System described below, in 2006 FHWA and the Missouri DOT developed and tested a prototype Weather Response System (WRS) for transportation system operations. The WRS was intended to use road weather information from the NWS, the private sector, state agencies and other sources to support transportation control, maintenance and operations decision-making. The results of the test and evaluation will be used to improve the prototype and bring it closer to statewide deployment.

Support for Maintenance Managers

The Maintenance Decision Support System (MDSS) project is a multi-year, FHWA-sponsored effort that was envisioned to assist transportation managers and operators improve roadway levels of service during winter weather events while minimizing road treatment costs (e.g., by optimizing use of labor, materials, and equipment). This data management tool has an ensemble of advanced weather prediction and road condition prediction capabilities, including air and pavement temperatures, precipitation start/stop times, precipitation types and accumulation amounts. These predictions are fused with customized winter road maintenance rules of practice to generate route-specific treatment recommendations (i.e., strategy, timing, and material application rates).

In the spring of 2003, the first functional MDSS prototype was demonstrated and evaluated by three Iowa DOT maintenance garages. The main display of the demonstration prototype, shown in Figure 3-DOT-9, includes predicted weather and road conditions, a weather parameter selection menu, a map of roads and weather alerts, as well as forecast animation controls. During the winter of 2004-2005, the demonstration domain was moved to Colorado to assess prototype capabilities over more complex terrain. Based on lessons learned from the preliminary demonstration in Iowa, the subsequent releases of Versions 2.0 and 3.0 in 2003 and 2004 respectively, and the Colorado demonstration, Version 4.0 was made available in November 2005.

Lessons learned, recommended enhancements and the future directions of the program were addressed and discussed during the 8th annual stakeholder meeting that was held in Falls Church, Virginia in August 2006.

The MDSS development process has moved forward to the point where the AASHTO Technology Implementation Group (TIG) proclaimed it to be a "2006 ready-to-implement technology" (AASHTO Journal 4/7/2006). Such a designation by one of FHWA primary partners will significantly support the deployment of MDSS. In addition, FHWA and its partners have worked together to see the MDSS project evolve from prototype development to proactive outreach, deployment assistance, technology transfer, and expansion of the functionality to other applications, such as summer maintenance and traffic management, and even other surface transportation sectors. This change is consistent with the FHWA's original deployment strategy, which included creating an environment that enables the private sector to build end-to-end products using core MDSS prototype functionality/technology as their foundation. These products will be procured by public agencies (e.g., state DOTs), enabling both the private and public sectors to benefit from millions of dollars of high-risk research. One example of technology transfer is the MDSS Pooled Fund Study (PFS) project led by the South Dakota DOT. Other participants include the state DOTs in Colorado, Indiana, Iowa, Minnesota, Kansas, Wyoming, New Hampshire and North Dakota, as well as Aurora (a pooled fund research program), a private vendor, and the FHWA. The objective of the project has been to build, evaluate, and deploy an operational MDSS by refining model components and conducting extensive field tests.

An example of proactive outreach has been the development and deployment of the "MDSS Road Show" by the FHWA Resource Center. This free seminar, which includes both an Executive Briefing and a Shop Session, is available to transportation managers, maintenance engineers and operators. The presentation describes the functions of MDSS, its capabilities, and its limitations. It also provides a level of detail that helps public agencies make more informed decisions about investing in such a tool.

Other FHWA-sponsored support activities planned for 2007 include: updating several components of the MDSS core system; overseeing the release of an enhanced version of the software; and conducting several cost/benefit analyses to generate quantitative results that can be used by the transportation community to justify investments in MDSS. Additional information on the MDSS project and the Road Show can be found at www.rap.ucar.edu/projects/rdwx_mdss and at http://ops.fhwa.dot.gov/Weather/index.asp.

<u>Support for Traffic Managers</u>

In 2006, the Road Weather Management Program developed a 5-year roadmap for Weather-Responsive Traffic Management. The roadmap identifies the goals and activities that FHWA will pursue in three major program areas: data collection and integration, impacts of weather on traffic flow, and traffic management strategies. The roadmap also serves as the basis for future work to identify, develop, test, and evaluate a variety of weather-responsive traffic management strategies.

Empirical studies of traffic flow and driver behavior during inclement weather are currently underway and will be completed in 2007. The Road Weather Management Program is working with FHWA's Office of Operations Research and Development to collect empirical traffic, weather, and pavement condition data on both freeway and arterial routes to quantify weather impacts on driver behavior, traffic speeds, traffic volumes, and travel time delay. This research will improve the understanding of how traffic flow and driver behavior change under adverse weather conditions. Once these factors are better understood, the information can be incorporated into traffic simulation models and, ultimately, traffic information and control tools.

<u>511-The National Traveler Information Telephone Number</u>

Based on the concept that a standardized number for travel information would be beneficial to the traveling public, a broad coalition of ITS interests worked together to allocate a national 511 traveler information telephone number. In 2002, the FHWA sponsored a number of grants to plan for state deployment of 511 services, and guidelines were issued on service content. A survey on traveler information conducted by ITS America indicated that weather and road condition information were highest in demand by travelers, and therefore, this type of information is considered a key component of 511 services. The means of delivering information through 511 are still being developed, including ways to serve peak demands for emergency evacuation information, as part of the homeland defense, or other threat capability.

In June 2003, the 511 Deployment Coalition released a *Deployment Assistance Report, Weather and Environmental Content on 511 Systems,* to recommend basic content and provide for consistency in 511 systems as they are deployed across the country. Since these systems are in their infancy, gaps exist in defining the types of road weather information travelers' desire, appropriate data formats, and the frequency and detail needed for travelers to make safe and effective decisions. The Road Weather Management Program has participated in several 511 Deployment conferences, including the one held in San Diego, California in July 2006, and continues its efforts to help establish road weather data requirements and close these gaps. The 511 program must also find ways to complement NOAA Weather Radio broadcasts, and use the NWS official watches and warning information. The 511 capability is just one more way in which ITS is becoming a significant dissemination means for road weather information. As of May 2006, 511 services were operational in 22 states, available to 32 percent of the population, and expected to be launched in eight more states by the end of the year (Figure 3-DOT-10).

<u>Weather Impacts on Roadway Safety, Mobility & Productivity</u>

While the impacts and associated costs of adverse weather on surface transportation are considered to be immense, it has been difficult to quantify specific costs related to these impacts. This is also true of the benefits (as avoidable costs) that are achieved through better information that helps support more effective responses and/or mitigation strategies. It is likely that the costs to mobility, in terms of delay due to weather, are the most significant part of this economic picture. For example, initial estimates of the economic impact of weather-related delay on trucks in the 20 major

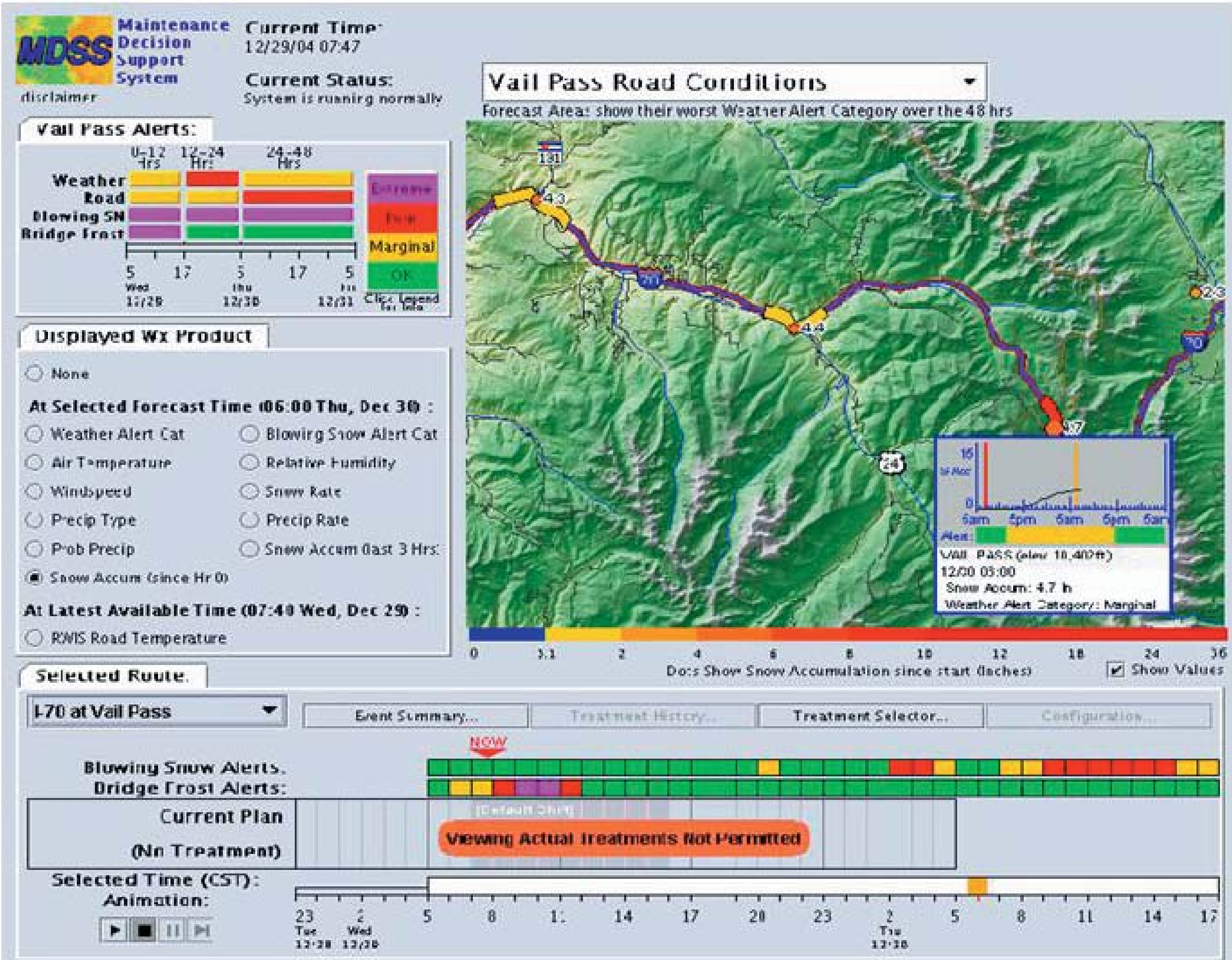


Figure 3-DOT-9 . Schematic of FHWA's Maintenance Decision Support System.

metropolitan areas most affected by adverse weather are on the order of $2 billion per year.

In an attempt to get a better understanding on the relationship between adverse weather and traffic delays, the FHWA sponsored a series of analyses that were conducted for the Seattle, Washington and Washington, DC metropolitan areas. These analyses combined surface weather observations with traffic speed data, both empirical and modeled. The results were consistent in showing about a 12 percent increase in travel time averaged over a wide range of weather events. A second analysis of delay effects in Washington, DC was conducted with archived Doppler radar data for more precise and more dynamic inference of road weather conditions. Analysis results indicated that during peak travel periods, travel time increased by roughly 24 percent when precipitation was present. It is the FHWA's belief, that achieving a better understanding of weather-traffic interactions, will lead to an improved ability to mitigate the impact of weather-related delays through traffic management practices, including speed management, access control (e.g., road closure), motorist warning systems, and weather-responsive signal timing.

Road Weather Management Program Outreach and Training

The Road Weather Management Program web site (http://www.ops.fhwa.dot.gov/Weather/index.asp) contains a wealth of information on the program. This includes material objectives and initiatives, weather impacts, benefits of road weather management strategies, technologies to help mitigate weather impacts, best practices, training, upcoming events, a listing of over 200 road weather related publications, and 30 case studies of road weather management systems. Each case study has six sections including a general description of the system, system components, operational procedures, resulting transportation outcomes (i.e., improved safety, mobility and/or productivity), implementation issues, as well as contact information and references.

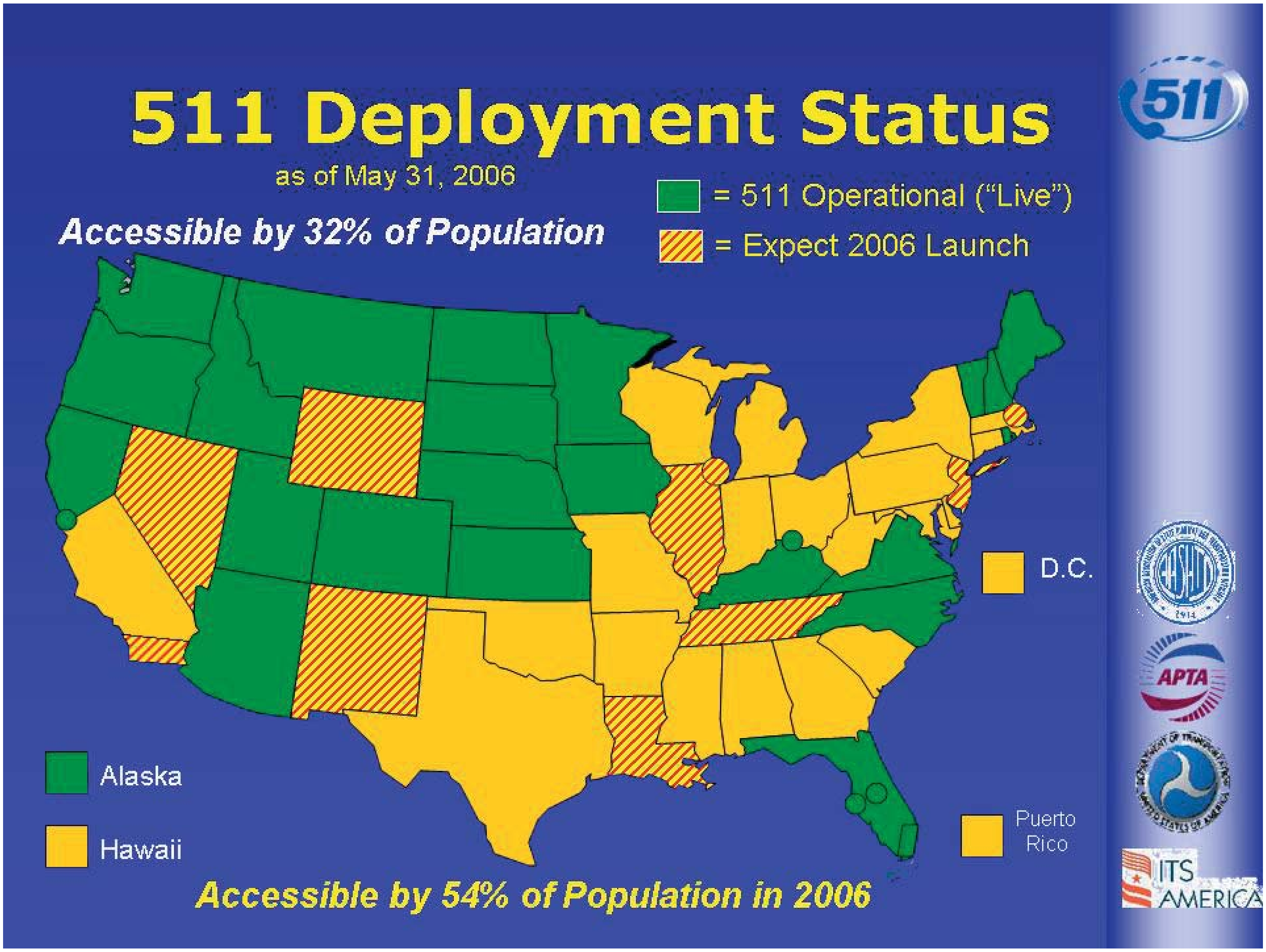


Figure 3-DOT-10 . 511 National Traveler Information Telephone Number Deployment - May 2006.

A key outreach activity of the program is the annual *Eastern Winter Road Maintenance Symposium & Equipment Expo* (or *Snow Expo*). Over the past eleven years, FHWA has partnered with state agencies to host the *Snow Expo*, which provides a forum for sharing information and technologies used to counter the effects of winter weather. AASHTO is now the lead sponsor, with FHWA as a co-sponsor. More information on the *Snow Expo* can be found at www.easternsnow-expo.org.

The FHWA sponsors training programs and conducts outreach to promote Road Weather Management Program products and activities. In 2005, a one-day training course on *Principles and Tools for Road Weather Management* became available through the National Highway Institute (NHI course No. 137030A). The course is aimed at helping those involved in highway maintenance and operations develop techniques and strategies for tackling road weather problems. The course will provide basic knowledge of meteorology and address the technological resources available to support highway personnel in making effective road weather management decisions. Additional details are listed on National Highway Institute web site (www.nhi.fhwa.dot.gov).

The computer-based *Anti-Icing/RWIS Training Program* is a comprehensive, interactive training program for winter operations that was jointly developed by AASHTO, with support from FHWA and Aurora. The training program covers an introduction to anti-icing and winter maintenance, winter road maintenance management, winter roadway hazards and principles of overcoming them, weather basics, weather and roadway monitoring for anti-icing decisions, computer access to road weather information, and anti-icing practice in winter maintenance operations.

The Federal Railroad Administration (FRA) supports improving the collection, dissemination, and application of weather data to enhance railroad safety through the Intelligent Weather Systems project, as part of the Intelligent Railroad Systems and Railroad System Safety research programs. These programs address safety issues for freight, commuter, intercity passenger, and high-speed passenger railroads.

Intelligent weather systems for railroad operations consist of networks of local weather sensors and instrumentation - both wayside and on-board locomotives - combined with national, regional, and local forecast data to alert train control centers, train crews, and maintenance crews of actual or potential hazardous weather conditions. Intelligent weather systems will provide advance warning of weather caused hazards such as flooding; track washouts; snow, mud, or rock slides; high winds; fog; high track-buckling risk; or other conditions which require adjustment to train operations or action by maintenance personnel (Figure 3-DOT-11).

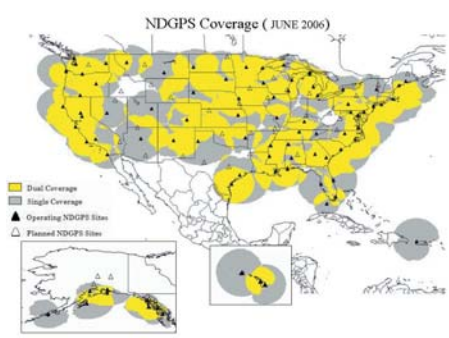
Figure 3-DOT-11. Track washed out by flood waters from Hurricane Alberto.

Weather data collected on the railroad could also be forwarded to weather forecasting centers to augment their other data sources. The installation of the digital data link communications network is a prerequisite for this activity.

FRA intends to examine ways that weather data can be collected on railroads and moved to forecasters, and ways that forecasts and current weather information can be moved to railroad control centers and train and maintenance crews to avoid potential accident situations. This is one of the partnership initiatives identified in the National Science and Technology Council's *National Transportation Technology Plan*.

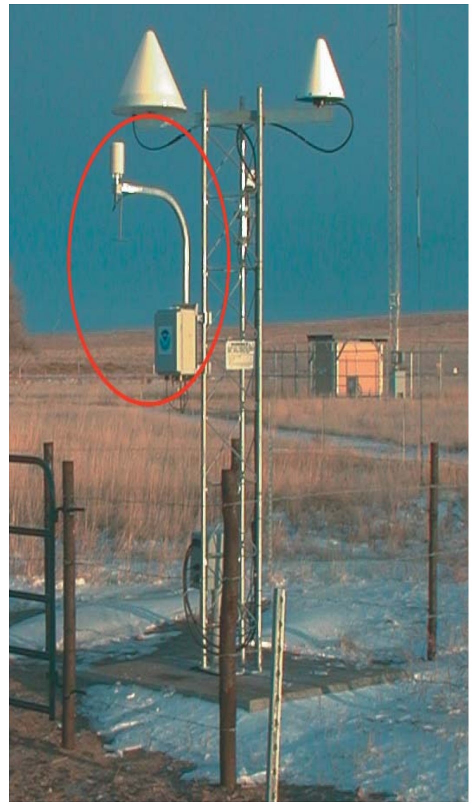
WEATHER FORECASTING ENHANCED BY NATIONWIDE DIFFERENTIAL GLOBAL POSITIONING SYSTEMS (NDGPS)

Nationwide Differential Global Positioning System (NDGPS) is a system of reference stations that monitors GPS and broadcasts corrections, which can be used by the GPS receiver to improve the accuracy, integrity and availability of the GPS position.



NDGPS is used in a myriad of applications including: maritime navigation, positive train control, precision farming, dredging, graphic information systems and surveying.

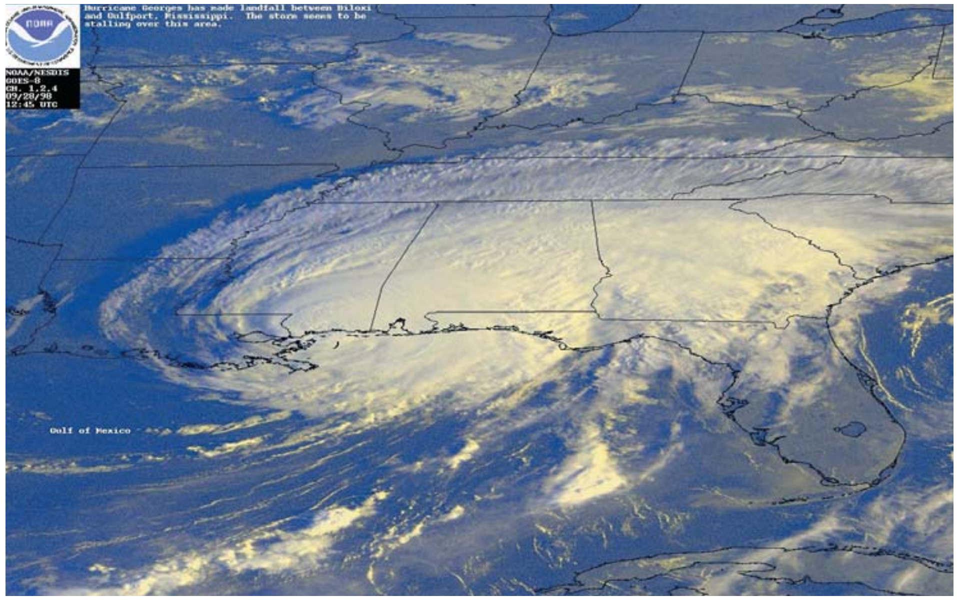
The Global Systems Division (GSD) of the Earth System Research Laboratory (ESRL) in the National Oceanic and Atmospheric Administration (NOAA) developed a unique application, which very accurately measures the amount of water vapor in the atmosphere by taking advantage of the dual-frequencies, reference station



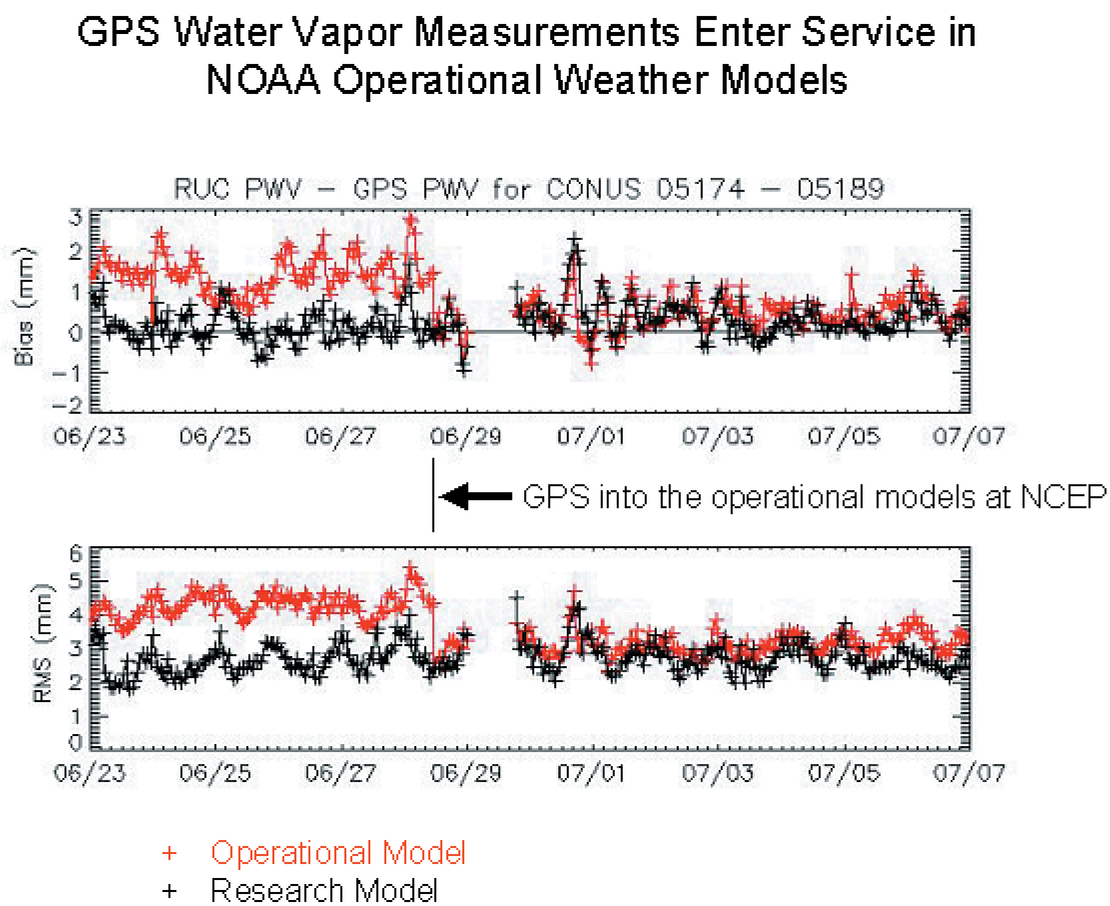
receivers at the NDGPS sites and a suite of weather sensors added to each reference station. The weather sensors, circled in the photo above, measure temperature, relative humidity and barometric pressure. The GPS satellites broadcast on two frequencies, L1 and L2. GSD uses these two frequencies to correct for the ionospheric delay that is caused by changes in the refractive index associated with the concentration of free electrons in the upper atmosphere. The ionospheric delay is usually about 6-10 times greater than the signal delay caused by the neutral, non-electrically conducting, atmosphere. GSD can than estimate the signal delays caused by the neutral atmosphere by comparing the errors in position between sites that are over 500 km apart by viewing the same satellites for about 30 minutes. Most of the delay in the troposphere (lower atmosphere) is caused by the mass of the atmosphere, or the hydrostatic component, while the induced dipole moment of the water vapor molecules in the atmosphere is responsible for the rest of the delay.

The GSD can accurately estimate the hydrostatic delay by putting a pressure sensor at the NDGPS site and mapping the surface pressure into signal delay using well-known physical relationships. Subtracting the hydrostatic delay from the observed tropospheric delay gives the wet signal delay caused by water vapor in the atmosphere. Then, the wet delay is mapped into the quantity of water vapor responsible for the delay using information about the temperature of the atmosphere and the characteristics of the air at microwave frequencies.

This results in the equivalent height of a column of water that would form if all of the water vapor in the atmosphere were to fall or precipitate. The total precipitable water vapor content is a direct measure of how much raw material is in the atmosphere in the form of rain, snow, hail and clouds. As the water vapor changes state from gas to liquid to solid and back again, it releases or absorbs energy associated with the latent heat bound-up in the molecules. This energy release and absorption is the primary energy responsible for weather. The reason that water vapor is hard to measure is that it only manifests itself when it changes state, and most instruments that can observe water in its gaseous state do not work well under all weather conditions. However, NDGPS works remarkably well in all weather conditions.



Water vapor is the most important



component of weather and the least observed. In June 2005, the research and development program to evaluate the use of NDGPS data became an operational program feeding near-real time date into NOAA's operational models. The addition of this data has greatly improved the model and short-term weather forecasts, especially during periods of active weather such as fronts, hurricanes or tornadoes.

The Federal Railroad Administration will continue to work with NOAA's GSD and the Coast Guard to install weather sensor systems at all of the NDGPS sites as they are built.

NATIONWIDE SURFACE TRANSPORTATION WEATHER OBSERVING AND FORECASTING SYSTEM - *CLARUS*

The weather products available today through both public and private resources are typically insufficient to meet the demands of transportation operations. Nearly all weather forecasting today is based on observations of the atmosphere. However, the greatest impact of weather events on the safety and mobility of travelers and freight occurs on the surface. Many state DOT's have invested in road weather information systems that provide their agencies with observations on conditions at the surface and just below the surface. Other entities such as agriculture, water districts, electric utilities, and railroads also operate weather observation stations. FRA is developing a partnership with the Federal Highways Administration (FHWA), state DOT's, NOAA and others to establish a nationwide road weather observation network known as *Clarus*. The goal of the *Clarus* project is to tie this mosaic of private and public observation stations into a cohesive weather forecasting system that is specifically focused on surface conditions.